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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : G06K 9/00	A1	(11) International Publication Number: WO 00/39743 (43) International Publication Date: 6 July 2000 (06.07.00)

(21) International Application Number: PCT/US99/30370

(22) International Filing Date: 17 December 1999 (17.12.99)

(30) Priority Data:

60/114,043	28 December 1998 (28.12.98)	US
09/370,408	9 August 1999 (09.08.99)	US

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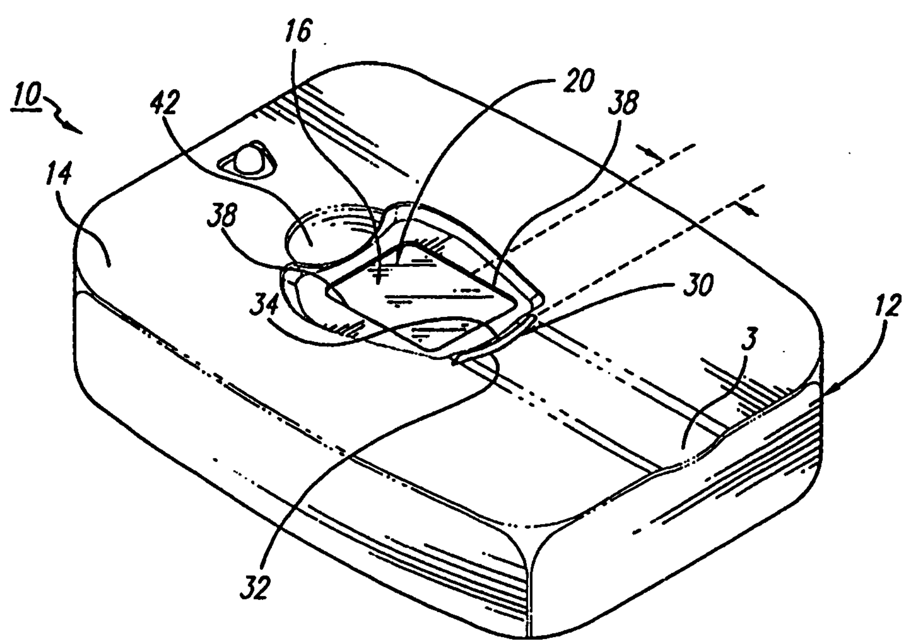
(81) Designated States: AE, AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), DM, EE, ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: APPARATUS AND METHOD FOR SENSING FINGERPRINTS



(57) Abstract

A device (10) and method for repeatedly and accurately sensing a fingerprint, wherein the finger with the fingerprint to be sensed is precisely located and maintained relative to a sensor (20). In particular, a transverse ridge (32) is engagable by the crease at the first joint of the finger to position and maintain the fingerprint longitudinally with respect to the sensor (20). The ridge (32) may have an arcuate center depression (34) to receive and center the finger in the transverse direction. Also, further guide structure may be provided such as a

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APPARATUS AND METHOD FOR SENSING FINGERPRINTS

Field of Invention

Sensing and verifying fingerprints, and particularly precisely locating a finger for such purpose.

Background of Invention

Fingerprint capture, i.e., sensing and verifying fingerprints, is a rapidly growing field. Initially these devices utilized optical means. Rather than utilize every feature or detail of a fingerprint, they selectively chose a limited selection of features such as intersection points to define a fingerprint. This worked reasonably well so long as all or most of the fingerprint was sensed. Thus, for repeatable high-accuracy sensing a relatively large sensor that would capture essentially the full fingerprint was required. Such optical sensors range in size from about 10 x 20 mm to about 25 x 40 mm. The cost of such devices can be relatively high, in the nature of several hundred dollars.

Newer solid-state technology is emerging utilizing microprocessor boards with advanced silicon capacitance-based sensors. The cost of these silicon sensors is directly related to their size. Obviously from a cost standpoint, the smaller the better. Such silicon sensors generally range in size from about 12.5 x 12.5 mm to about 15 x 20 mm. To permit the use of silicon sensors on a practical and economical basis, advanced fingerprint analysis algorithms have been developed. These algorithms permit high-accuracy fingerprint identification based on sensing only the core area of a fingerprint rather than the full fingerprint. Generally a region about 10 mm in diameter is sufficient. This in turn allows use of relatively small size less expensive silicon sensors that need only sense the fingerprint core area.

The optical sensors that sampled a full fingerprint did not demand as high a degree of alignment between the sensors and the fingerprint as required for the silicon sensors. Prior techniques for alignment of a fingerprint with a sensor did not provide the desired high degree of repeatable high-accuracy fingerprint verification when used with the smaller silicon sensors. Such prior techniques provided reasonable transverse or side-to-side locating, but were significantly lacking in longitudinal locating. In particular,

efforts to utilize the end of the finger being sensed have produced less than desired results. The primary problem is that the distance from the finger tip to the fingerprint core area tends to vary significantly from person to person. Further long finger nails will also contribute to this problem.

Summary of the Disclosure

The illustrated devices and methods repeatedly and accurately locate a finger for purposes of sensing the finger's fingerprint. A ridge or rib that extends transversely of the finger is engagable by the crease at the first joint of the finger. This ridge is spaced a predetermined distance from the center of the silicon sensor measured longitudinal, i.e., in the direction in which the finger extends. The preferred ridge to sensor center distance is approximately 12.5mm for fingers and 15.0mm for thumbs. This ensures that the core will lie in the field of view of the sensor. It also maintains the core at the desired location by not allowing the finger to move or longitudinally slide off the sensor. More particularly, one of the key failure modes for fingerprint comparison is the presence of large distortion in the measured fingerprint image. Large distortions result when the finger is slid across the sensor surface. The presence of the ridge makes it uncomfortable for the user to slide their finger along the sensor surface and thereby discourages large distortion. When used correctly, the finger makes contact with the senor surface only after ridge has settled into the crease, locking the finger in place.

Placing the ridge at a fixed distance from the center of the sensor has another beneficial effect. It facilitates comparisons of fingerprints collected using different sensors of varying geometry. In this way, it makes fingerprint verification sensor independent.

As noted above, there is currently a progression underway from historical optical senors to the newer solid-state sensors. These two classes of sensors are characterized by dramatically different geometries. The optical sensors are generally large, while solid-state sensors are small. Users of historical sensor technology would like an upgrade path to the newer technology.

The ridge provides a very reliable method for preserving the utility of current enrollments. By locating the ridge at a fixed distance from the center of each sensor, enrollments on one sensor type can be compared to live scan fingerprints from another

sensor. The ridge provides a point of reference by ensuring that the user's finger is consistently placed and locating the crease of the user's finger a fixed distance from the center of the sensor for both sensors. This is illustrated in Figures 8a and 8b.

Sensor independence can be further enhanced by creating an ergonomic "universal" fingerguide that appears identical to the user, but in fact contains sensors of varying types. Such a mask could be envisioned as a rectangular unit having a rectangular aperture matched to the sensors active area. The top of the mask would also contain a finger trough to guide finger placement and the ridge. The bottom of the mask would provide sensor specific mounting supports (invisible to the user).

In this way, upgrading a device could be as simple as removing a finger mask with one sensor and replacing it with a same sized mask, but containing a completely different sensor.

This arrangement has been found to produce highly repeatable and accurate sensing of fingerprints, including in particular sensing of the core area of a fingerprint using a small size silicon sensor.

In one form, the ridge has an arcuate depression at its center which receives and centers the finger in the transverse direction. Further, a physical structure (a projection or a depression) may be provided centrally to engage the tip of the finger. The finger is thus guided by the "feel" of the guide structure, i.e. the ridge and the center finger-tip structure, to the proper position. The finger is thus accurately located longitudinally, as well as transversely.

To further contribute to this comfortable feel and proper location, a longitudinal channel or depression may also be provided. Further, the side edges of a window or cutout that provides access to the sensor may also assist in transverse locating of the finger.

In an alternate preferred embodiment, the ridge may be transversely generally linear without the center recess, and transverse positioning means may be provided such as spaced-apart parallel side rails to engage the sides of the finger.

In one form, the device may be a self contained unit having a housing. The housing has an upper wall that provides the finger locating ridge and other locating structure. The upper wall also has the window which is aligned with the silicon sensor.

This device also includes electronic means for storing fingerprint templates, for comparing the sensed fingerprint data for a designated person with the stored template for that person, and for providing output based on the result of that comparison. The output may actuate an indicator such as a 3-color LED mounted on the housing. The output may also provide an electrical signal through a serial port on the housing for controlling other apparatus such as time and attendance apparatus or security entry control apparatus.

Alternatively the device may be provided as an OEM unit for incorporation into another apparatus which may have its own template storage capacity and/or its own comparison capacity. The sensing device would then need only to sense the fingerprint data and pass it along to the other apparatus.

In the Drawings

Figure 1 is a perspective view of a self-contained fingerprint sensing and verifying device that is a presently preferred embodiment of the invention.

Figure 2 is a schematic enlarged view of the locating ridge of the device of Figure 1.

Figure 3 is a further enlarged sectional view through the ridge of Figure 2.

Figure 4 is a schematic diagram of components of the device of Figure 1.

Figure 5 is a schematic view of an alternative embodiment of locating structure.

Figure 6 is a top plan view of a finger mask that is also a presently preferred embodiment of the invention.

Figure 7 is a side sectional view of the finger mask of Figure 6.

Figures 8a and 8b are schematic views illustrating optical and sold-state sensors relative to a ridge guide.

Detailed Description Of The Drawings

Figures 1-4 illustrates a presently preferred form of the invention as a self-contained fingerprint sensing and verifying device or apparatus 10. This device 10 utilizes an advanced silicon capacitance-based sensor 20 to sense the core area of a desired fingerprint. The device 10 also operates to verify the authenticity of the fingerprint is belonging to a specified person. In this regard, the sensed data as to the fingerprint core area is compared to a template of the fingerprint core area of that person.

The success or failure of the verification may be presented as a red or green light from a 3-color LED. Output from the device 10 may also operate other apparatus, such as a door lock or a time clock, based on the verification result.

To accommodate the relatively small size of the silicon sensor 20, the device 10 includes finger locating or positioning means 30 to precisely locate and maintain the fingerprint core area of the finger in alignment with the silicon sensor. The illustrated silicon sensor 30 is generally rectangular, measuring from approximately 12.5 x 12.5 mm to approximately 15 x 20 mm. The illustrated positioning means 30 includes a transversely extending ridge 32 with a centered arcuate recess 34. The ridge 32 is spaced approximately 12.5 to 15mm from the center of the silicon sensor 20, measured longitudinally.

More particularly, the illustrated device 10 has a generally rectangular housing 12. The housing 12 has an upper wall 14 with a rectangular window 16 in the form of a cut out to provide access to the silicon capacitance-based sensor 20 mounted in the housing. The window 16 is positioned generally centrally of the upper wall 14. The sensor 20 may be mounted on a mezzanine microprocessor board 22 that is secured to the underside of the upper wall 14 so that the sensor extends generally horizontally immediately below the window 16. The housing 12 may be a molded plastic or silicone formed with positioning or locating guide means 30 on the upper wall 14. In this regard, the illustrated guide means 30 includes an elongated shallow channel groove or recess 36 that receives and locates the finger. The illustrated channel 35 has a curved or arcuate cross section. The direction of the channel 36 and the finger received therein will be referred to herein as the longitudinal direction or dimension. The direction or dimension at right angles to the channel 36 will be referred to herein as the transverse direction or dimension. The channel 36 extends over the window 16.

Extending transversely across the channel is the upright ridge or rib 32 for engaging the finger crease at the first joint of the finger. The upper edge of the illustrated ridge 32 is generally rounded with a diameter of about 1 mm. The illustrated ridge 32 has a height of about 2 mm and a width of about 1 mm. As shown best in Figure 2, the ridge 32 follows the arcuate curve of the channel 36 whereby the center portion of the ridge forms the curved center recess 34. This center recess 34 of the ridge serves to receive and

position the finger at its first joint generally centered and transversely aligned with the sensor 20. The ridge 32 is located about 12.5 to 15mm spaced longitudinally from the center of the sensor. When the crease of the finger is on the ridge 32, the core area of the finger's fingerprint will be generally centered over the sensor 20. The ridge tends to maintain the finger in this position, limiting longitudinal sliding or movement of the finger relative to the sensor 20. This facilitates the high–accuracy sensing of that core area. The range from 12.5 to 15mm is a practical but workable compromise. The more precise measurement for the thumb is about 16 mm ±3 mm standard deviation. The more precise measurement for the other fingers is about 12.5 mm ± 2.5 mm standard deviation. The use of a distance in the range of about 12.5 to 15mm allows the device to be used for thumb and fingers. Devices may have a ridge distance selected based on the application. For example, a key chain device would generally verify the thumb print.

The transverse positioning of the finger is also facilitated by the longitudinal channel 36, and by the side edges 38 of the window 16.

As shown in Figure 1, the area of the channel 36 around the sensor window 16 is hollowed out by a shallow curved depression 40 which can help accommodate larger fingers and aid in finger locating, as well as offering a more comfortable feeling to the user. The forward end 42 of the channel 36 provides a center locating guide for the tip of the finger. This helps to prevent the finger from being tilted or angled away from the longitudinal direction. The entire channel 36 serves to ensure that the finger is pressed as flat as possible against the sensor 20, which contributes to accurate sensing. The sensor is so constructed that the finger can be pressed against it without harming the sensor or distorting the accuracy of the sensed data, and in fact such contact enhances the sensed data accuracy.

Figure 4 illustrates schematically the electronic components of the device 10. The mezzanine board 22 on which the silicon sensor 20 is mounted is connected to a main processing board 24. The main processing board 24 provides various control and operational functions. Initially, when the board 24 is set to enrollment mode, data as to the fingerprints of various persons is sensed and then stored as data in the form of templates of the fingerprints belonging to the particular persons. Subsequently, when the board 24 is set to sensing and verifying mode, data sensed as to the fingerprint of a

designated person is compared to the data or template of that person. Finally, operating in its control function, the board 24 provides an output signal based on the results of the comparison. This output signal may operate an external apparatus such as a door lock 26. The output signal may also operate an indicator 28 such as a 3-color LED on the housing 12, or provide a sound indication or the like.

Figure 5 shows an alternate configuration of finger locating structure 130 where the ridge 132 is generally transversely linear without a center recess. Side-to-side and anti-tilting positioning are provided by a pair of upright longitudinally extending side rails 144. This alternate configuration is somewhat simpler and less costly than the configuration of Figures 1–4 but it tends not do provide as good or consistent results.

Figures 6 and 7 illustrates a finger mask unit 210 that is also presently preferred. Finger mask unit 210 is not self-contained but is designed for integration into another piece of external OEM equipment or apparatus such as a time clock. This illustrated finger mask unit 210 includes a container section 212. Container section 212 holds a mezzanine board 22 on which is mounted an advanced silicon capacitance-based sensor 220. The illustrated finger mask unit 210 includes a side section or flange 218 at either side of the container section 212 for mounting the finger mask unit to the case 219 of the OEM equipment by suitable means such as screws (not shown). The container section 212 has an upper wall 214 that provides finger locating or positioning means 230. The illustrated locating means 230 includes a transverse ridge 232 with an arcuate central recess 234 for locating and maintaining the finger position, particularly longitudinally. The locating means 230 also includes a longitudinal finger receiving channel 236 with a finger-tip receiving forward end 242.

This finger mask unit 210 may interface with the time-keeping machine that stores the fingerprint data templates, does the comparisons, and provides the verification output to control the machine. The finger mask unit 210 would simply do the sensing and provide the sensed data as to be fingerprint to the time-keeping machine.

Various other modifications and changes may be made to the illustrated structure without departing from the spirit and scope of the present invention as set forth in the claims.

Claims

1. A fingerprint sensing device comprising:

a) a fingerprint sensing means having an input sensor with a longitudinal dimension and a transverse dimension,

b) a finger-positioning structure for positioning and maintaining a finger with a fingerprint to be sensed extending in the longitudinal direction relative to the input sensor and positioned adjacent to and aligned with the input sensor, said finger-positioning apparatus including

1) a support surface to receive and support said finger,

2) a window in the support surface, said window being generally aligned with said input sensor,

3) locating means on the support surface including a projection for engaging the end-most joint of said finger to locate and maintain the finger with its fingerprint generally aligned as measured in the longitudinal dimension with said input sensor.

2. The apparatus of Claim 1 wherein said projection is in the form of a transversely extending ridge having a generally centered recess to receive the finger at said joint so as to locate that finger joint generally centered as measured in the transverse dimension.

3. The apparatus of Claim 1 wherein said locating means includes additional structure for engaging the finger so as to locate said finger generally centered as measured in the transverse dimension.

4. The apparatus of Claim 3 wherein said additional structure is in the form of a recessed channel extending longitudinally and generally centered as measured in the transverse dimension.

5. The apparatus of Claim 3 wherein said additional structure is disposed generally centered as measured in the transverse dimension and positioned to engage the end tip of the finger.

6. The apparatus of Claim 3 wherein said additional structure is in the form of a pair of longitudinally extending generally parallel spaced apart side rails.

7. The apparatus of Claim 1 wherein said input sensor is a capacitance based silicon

sensor of a size to sense the core area of the fingerprint but not the full fingerprint.

8. The apparatus of Claim 1 wherein said projection is located about 12.5 to about 15.0mm as measured in the longitudinal dimension from the center of said input sensor.

9. The apparatus of Claim 1 further including an electronic processor operable to receive and hold information identifying a particular person, and to receive and hold data from the input sensor about the fingerprint of a person purporting to be that person.

10. The apparatus of Claim 9 wherein said electronic processor is also operable to:

store information and data about a plurality of different persons and their fingerprints,

compare the received and held information and data for a particular person to the stored information and data for that person, and

send an output signal based on the results of the comparison.

11. The apparatus of Claim 9 wherein said electronic processor is also operable to send such information and data to an associated apparatus for comparison of such information and data with stored information and data relative to that person.

12. The apparatus of Claim 11 in the form of a generally self-contained unit configured and proportioned to be mounted on said associated apparatus.

13. A method of sensing a fingerprint, comprising:

providing a fingerprint sensing means having an input sensor, the input sensor having a longitudinal dimension and a transverse dimension, the sensing means being adapted to sense the fingerprint of a finger extending generally in the longitudinal direction relative to the input sensor and positioned adjacent to and aligned with the input sensor,

causing the first digit of the finger with a fingerprint to be sensed to engage a physical structure so as to generally center that finger digit as measured along the transverse dimension of the input sensor, and

causing the first joint from the end of said finger to engage a projection that is spaced a predetermined distance measured in the longitudinal dimension from the center of the input sensor,

whereby the fingerprint of the finger is aligned with the input sensor and maintain in that position for high-accuracy sensing of the fingerprint.

14. The method of Claim 13 further including causing the forward end of the finger to engage a physical structure that is generally centered as measured along the transverse dimension of the input sensor.

15. The method of Claim 13 further including causing the second digit of the finger to engage a physical structure so as to generally center that digit as measured along the transverse dimension of the input sensor.

16. The method of Claim 13 wherein the input senor is a capacitance-based silicon sensor of a size to sense the core area of the fingerprint but not the full fingerprint.

17. The method of Claim 13 wherein said predetermined distance is about 12.5 to about 15mm.

18. For use with a fingerprint sensing apparatus that includes a fingerprint sensing means having an input sensor with a longitudinal dimension and a transverse dimension,

a finger-positioning structure for positioning and maintaining a finger with a fingerprint to be sensed extending in the longitudinal dimension relative to the input sensor and positioned adjacent to and aligned with the input sensor, said finger-positioning apparatus including

1) a support surface to receive and support said finger,

2) a window in the support surface, said window being generally aligned with said input sensor,

3) locating means on the support surface including a projection for engaging the end-most joint of said finger to locate and maintain the finger with its fingerprint generally aligned as measured in the longitudinal dimension with said input sensor.

19. The apparatus of Claim 18 wherein said projection is in the form of a transversely extending ridge having a generally centered recess to receive the finger at said joint so as to locate that finger joint generally centered as measured in the transverse dimension.

20. The apparatus of Claim 18 wherein said locating means includes additional structure for engaging the finger so as to locate said finger generally centered as measured in the transverse dimension.

21. The apparatus of Claim 20 wherein said additional structure is in the form of a recessed channel extending longitudinally and generally centered as measured in the

transverse dimension.

22. The apparatus of Claim 20 wherein said additional structure is disposed generally centered as measured in the transverse dimension and positioned to engage the end tip of the finger.

23. The apparatus of Claim 20 wherein said additional structure is in the form of a pair of longitudinally extending generally parallel spaced apart side rails.

24. The apparatus of Claim 23 wherein said projection is located about 12.5 to about 15.0mm as measured in the longitudinal dimension from the center of said input sensor.

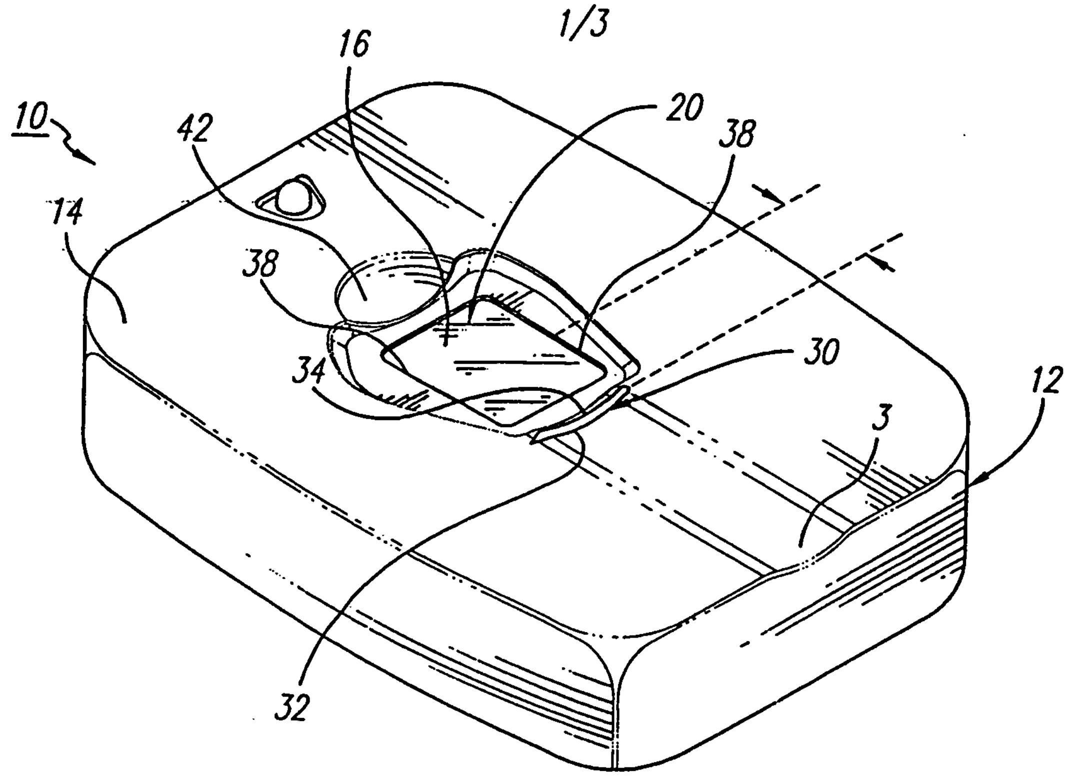


FIG. 1

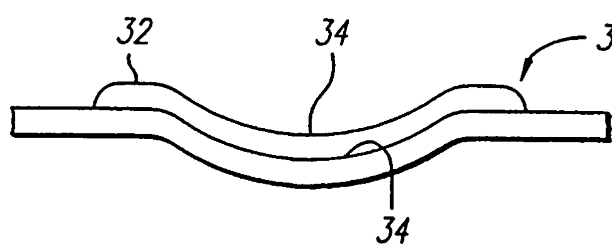
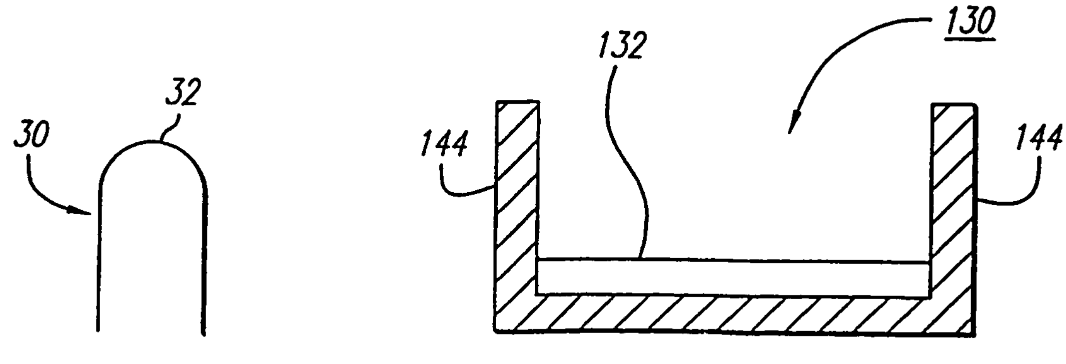
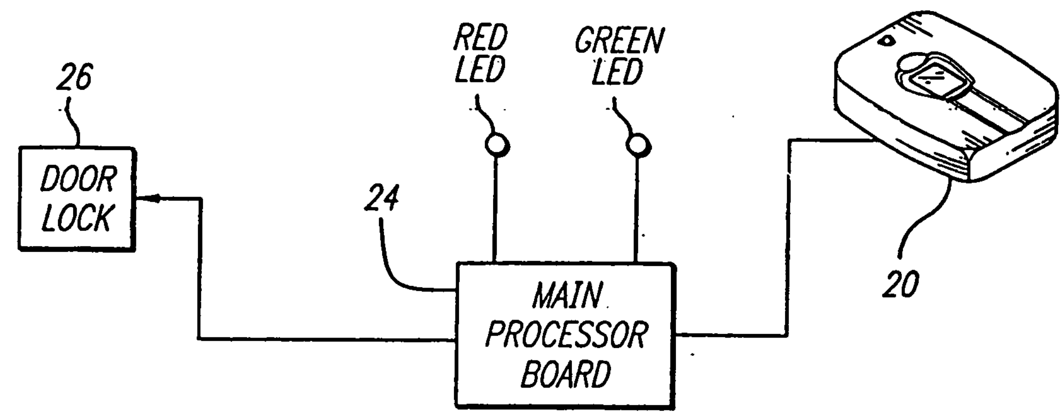


FIG. 2

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DOOR LOCK
RED LED
GREEN LED
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MAIN PROCESSOR BOARD
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FIG. 4

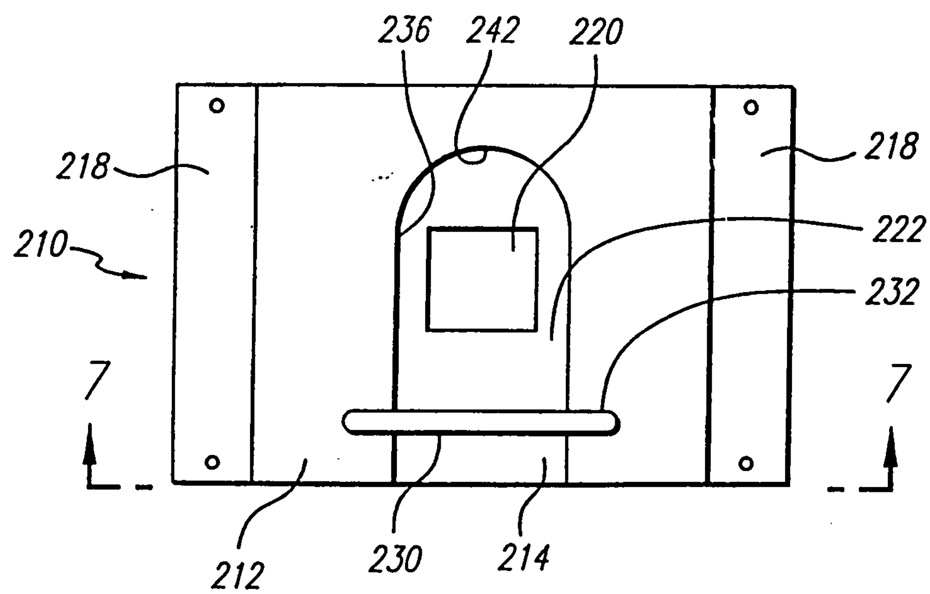
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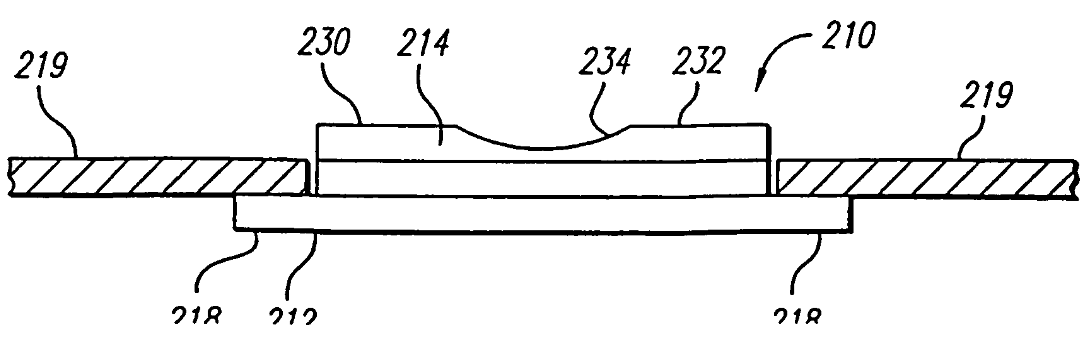
FIG. 6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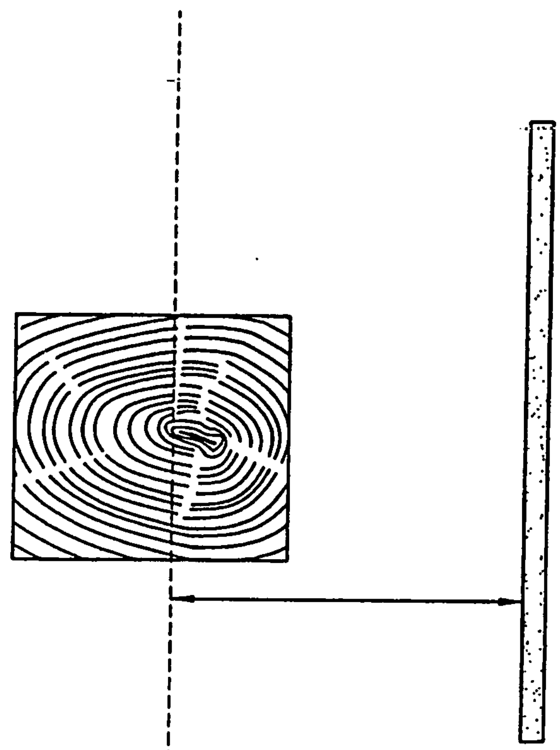

FIG. 8b

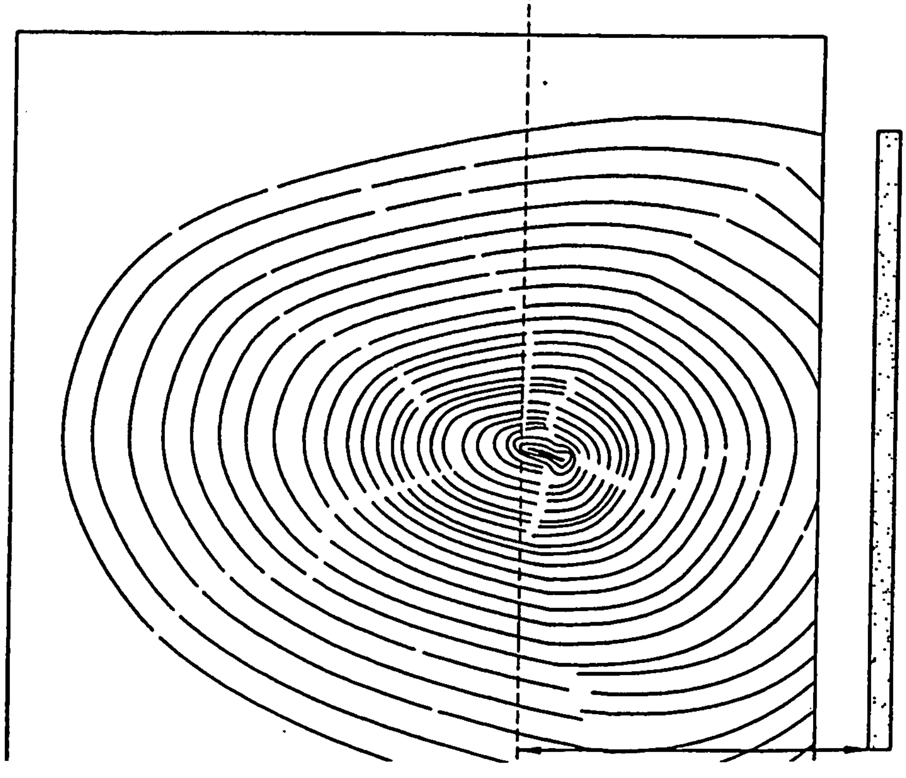

FIG. 8a

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/30370

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G06K 9/00
US CL :382/126
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 382/126

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 61-175865 (ISAO MIZUKURA) 07 AUGUST 1986, Abstract, Fig. 1	1-4, 6, 13-15, 18-21, 23,
X	US 3,975,711 A (MCMAHON) 17 AUGUST 1976 , Fig. 5	5,22
X	US 5,828,773 A (SETLAK ET AL.) 27 OCTOBER 1998, Figs 8,9, col. 5, line 65-col. 6, line 17 and col. 7, lines 62-67.	7-12, 16-17, 24
X	US 5,603,179 A (ADAMS) 18 FEBRUARY 1997, col. 1, lines 41-63.	10-12
X	US 4,394,773 A (RUELL) 19 JULY 1983, col. 4, lines 25-28, lines 40-42.	11-12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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